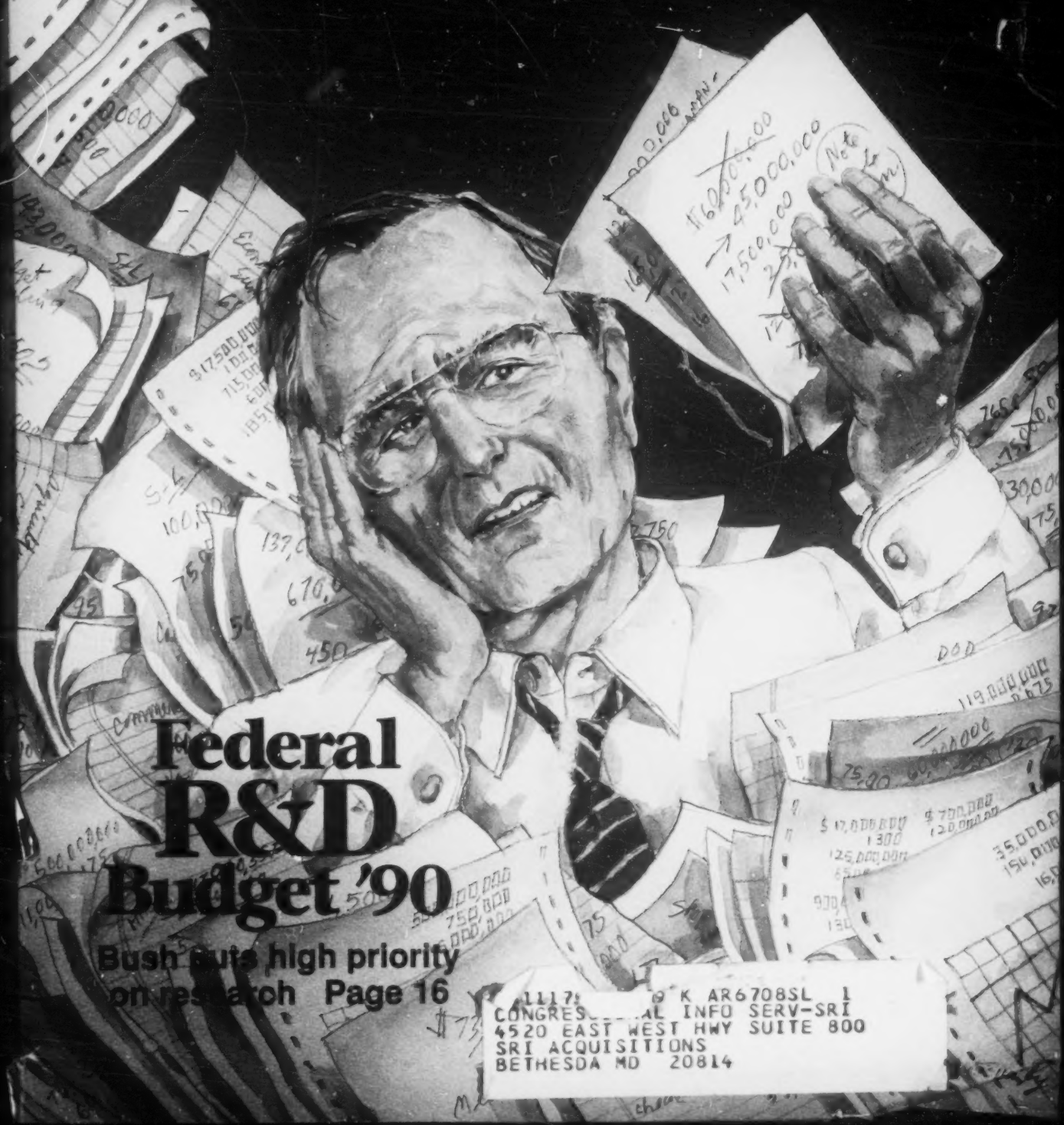
FEBRUARY 20, 1989
CHEMICAL & ENGINEERING

NEWS

Chemical industry earnings continued to rise strongly in fourth quarter Page 9



Federal R&D Budget '90

Bush puts high priority on research Page 16

1117? K AR6708SL 1
CONGRES AL INFO SERV-SRI
4520 EAST WEST HWY SUITE 800
SRI ACQUISITIONS
BETHESDA MD 20814

CHEMICAL & ENGINEERING
NEWS

Volume 67, Number 8
CENEAR 67 (8) 1–48
ISSN 0009-2347

FEBRUARY 20, 1989

News of the Week

■ **Union Carbide to pay Indian government $470 million as compensation to victims of 1984 methyl isocyanate disaster in Bhopal.** Page 4

■ **Institute of Medicine report urges universities to take steps to strengthen ethical standards in research.** Page 5

■ **In latest restructuring effort, W. R. Grace & Co. is exploring partial sale of its noncore businesses.** Page 6

■ **President Bush reaffirms his intentions for top role for White House science adviser.** Page 6

Business

Earnings of major U.S. chemical companies climbed an average 56% in the fourth quarter, capping a year of strong growth. **Page 9**

Plastics will keep their edge in competing with other materials in spite of price rises last year. **Page 14**

Science

Highly efficient route to synthesis of complex alkaloids features polycyclization reaction. **Page 22**

Technology

Scientists tackle challenge of putting superconductors to work, make most progress in thin-films area. **Page 24**

Books

"Collapse of an Industry" by John L. Campbell takes a look at how the American political process has worked against the nuclear power industry. **Page 29**

Government

President Bush's fiscal 1990 federal budget favors increased funding for science, particularly basic research, big science projects, and science education. **Page 16**

Letters 2

Concentrates
Business 7
Government 15
Science/Technology 21

The Departments
People 31
Awards 32
Newscripts 48

Chemical & Engineering News

1155—16th St., N.W., Washington, D.C. 20036

Editor: Michael Heylin
Assistant Managing Editors: David M. Kiefer, James H. Krieger, Janice R. Long, Donald J. Soisson, William J. Storck. **News Editor:** Wilbert C. Lepkowski
Staff Editor: Ernest L. Carpenter
Senior Editors: New York: Earl V. Anderson, Stephen C. Stinson. Chicago: Joseph Haggin; Washington: Doron Dagani, Lois R. Ember, Bette Hileman, Rebecca L. Rawls, Pamela S. Zurer
Associate Editors: Stuart A. Borman, Mairin B. Brennan, Richard J. Seltzer
Service Departments Editor: Dolores Miner
Editing Services: Anne Riesberg (Head), Arlene Goldberg-Gist (Editorial Assistant), Patricia Oates (Administrative Assistant)

News Bureaus: Northeast News Bureau: (201) 906-8300 Marc S. Reisch (Associate Editor), Ann M. Thayer (Assistant Editor), Rachel Eskenazi (Administrative Assistant). Chicago: (312) 256-4143 Ward Worthy (Head). Houston: (713) 973-8161 Bruce F. Greek (Head). Washington: (202) 872-4495 David J. Hanson (Head). West Coast: (415) 653-3630 Rudy M. Baum (Head). **Foreign Bureau:** London: (01) 540-0414 Dermot A. O'Sullivan (Head), Patricia L. Layman (Associate Editor)
Graphics and Production: Leroy Corcoran (Manager). Alan Kahan (Art Director). Barbara Fryer (Production/Art Director). Linda Mattingly (Staff Artist). Diane Kelly (Costing).
Business Manager: Arthur Poulos
Circulation Development: Claud K. Robinson

ADVISORY BOARD: Jacqueline K. Barton, Ernest H. Drew, Harry G. Drickamer, A. Nicholas Filippello, Adam Heller, Koji Nakanishi, Robert M. Simon, William P. Slichter

Published by
AMERICAN CHEMICAL SOCIETY
(202) 872-4600; TDD (202) 872-8733
John K. Crum, Executive Director

PUBLISHING BOARD: Jeanne M. Shreeve (*Chairman*); *Board of Directors Chairman*: Ernest L. Eliel; *President*; Clayton F. Callis, and four members of the Society Committee on Publications yet to be appointed

© Copyright 1989, American Chemical Society

Subscription & Member Record Service: Send all new and renewal subscriptions with payments to: Controller, ACS, P.O. Box 28597, Central Station, Washington, D.C. 20005. Correspondence and telephone calls for changes of address, claims for missing issues, subscription service, status of records and accounts should be directed to: Manager, Member & Subscriber Services, ACS, P.O. Box 3337, Columbus, Ohio 43210; (800) 333-9511 or (614) 447-3776.

For changes of address, include both old and new addresses with ZIP code numbers and mailing label from a recent issue. Allow four weeks for change to become effective. Claims for missing numbers will not be allowed if loss was due to failure of notice of change of address to be received in the time specified; if claim is dated (a) North America: more than 90 days beyond issue date; (b) all other foreign: more than one year beyond issue date; or if the reason given is "missing from files."

Subscription Rates 1989: Printed editions: nonmembers U.S. 1 yr. $55, 2 yr. $99, outside U.S. 1 yr. $86, 2 yr. $161. Air freight rates available on request. Rates above do not apply to nonmember subscribers in Japan, who must enter subscription orders with Maruzen Co. Ltd., 3-10 Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan. Tel: (03) 272-7211. Single copies: Current $7.00. Rates for back issues and volumes are available from Microforms & Back Issues Office, ACS, 1155—16th St., N.W., Washington, D.C. 20036. Back and current issues available on microfilm and microfiche. Rates on request from Microform Program, ACS.

Chemical & Engineering News (ISSN 0009-2347) is published weekly except for the last week in December by the American Chemical Society at 1155—16th St., N.W., Washington, D.C. 20036. Second-class postage paid at Washington, D.C., and additional mailing offices. POSTMASTER: Send address changes to Chemical & Engineering News, Membership & Subscription Services, P.O. Box 3337, Columbus, Ohio 43210. ACS assumes no responsibility for the statements and opinions advanced by the contributors to its publications.

Advertising Management
CENTCOM LTD.
(For list of offices see page 47)

LETTERS

Chemist sets example

SIR: Congratulations to Edward J. Poziomek, who received the Maryland Chemist of the Year Award for 1988. I feel that Poziomek is a dedicated chemist who has done a lot for the image of chemistry.

I recall an experience in grade school when he visited our classroom and spent several hours doing dramatic, thought-provoking experiments and answering questions about science. I feel that his lecture is responsible for my career commitment to chemistry. Following his example, I have taken just an hour out of the year to demonstrate an example of chemistry to my son's grade school class.

Thank you, Dr. Poziomek, and all scientists who are willing to devote a few hours to educating or communicating information about science to others. Certainly, ACS and National Chemistry Day or Week give everyone the opportunity to participate. Education has been proven the answer to long-range problems, time and again—all it requires is a little input from all of us.

G. Herold
Baltimore

Chemical industry for society

SIR: I was amazed to read a letter by Philip Sadtler (C&EN, Nov. 21, 1988, page 3) about a Rotary Club speech. This year, for the first time in our local schools, we the Rotarians of Ambarnath and members of Marathi Vidnyan Parishad, observed Chemistry Day on Dec. 3, 1988—the anniversary of the Bhopal tragedy.

We had six lectures and some demonstrations. The program was attended by more than 500 final year high school students and teachers. The speakers included a research manager of a local chemical unit (the undersigned), a professor of chemical engineering, a government technical officer in charge of pesticides, a consultant on environment, a director of a chemical unit, and a retired American research worker of Du Pont Co., who was visiting here. The theme of all the talks was "Chemical Industry for the Society." The speakers, one by one, explained to the young boys and girls how the chemical industry helps mankind to meet the primary needs of food, clothing, shelter, energy, and physical and mental well-being and clean environment through adoption of better technologies. The American scientist (also a Rotarian), who spoke, was so pleased with the 100-minute program that he said when he went back, he would start something like this in his hometown.

Such programs are important because good students have started shying away from chemistry and chemical engineering.

V. M. Vaidya
President, Rotary Club of Ambarnath, India

Polyethylene glycol

SIR: Anatomical features of wood help explain why "the efficiency of polyethylene glycol treatment is widely debated" (C&EN, Nov. 14, 1988, page 10). Roughly 25% of the volume of wood (density 0.4 g per cc) is that of the cell walls or wood substance—a complex network of lignin and polysaccharides. The remaining 75% is void volume. One hundred grams of wood, fully waterlogged, contain about 215 g of sorbed water, of which 35 g are adsorbed in the wood substance. The aim of treatment is to replace most of this adsorbed water with an equivalent volume of polyethylene glycol. Access to cell walls is by diffusion in the remaining 180 g of "free water." However, this water is confined in closed cells 10 to 40 μm in diameter and 1 to 3 mm in length. Diffusion of polyethylene glycol between cells occurs through membranes perforated with submicroscopic pores of varying effectiveness.

Here, then, is the reason for the long times required to treat large sections of waterlogged wood. At the cell walls,

Laboratory accident information wanted

Science teachers who have personal knowledge of a serious laboratory accident are invited to contribute their story for a manual on safety. It will be geared toward the middle school through junior college teacher, and will be a compilation of accidents or near misses that have actually taken place in the laboratory. Strict confidentiality will be observed. Send contributions to Clair G. Wood, Eastern Maine Vocational Technical Institute, 354 Hogan Rd., Bangor, Me. 04401.

Chemical Earnings Close 1988 With Continued Strong Growth

William J. Storck,
C&EN Northeast News Bureau

Gains in earnings among U.S. chemical companies in the fourth quarter capped a year of strong growth in the industry. Earnings for 29 major chemical companies increased an average of 56% in the quarter, and earnings at oil, diversified, and drug companies that produce chemicals also improved.

Although this is the slowest earnings growth rate for the year (the same group of companies registered growth of 66% in the first quarter, 70% in the second, and 65% in the third), it still portends well for the immediate future.

Sales for the 29 companies also increased, rising 16% for the quarter from the year-earlier level.

Higher prices and production contributed to the improvement during the period. Government figures show that prices for chemicals and allied products in the fourth quarter were up about 11% over the same period in 1987. And output for the final three-month period last year rose about 9% over fourth-quarter 1987.

Much of the strength for the quarter was in basic chemicals, as it has been in the previous periods. In fact, that strength in commodities is hurting some of the smaller specialty-oriented companies, whose profit margins are being squeezed by rapidly rising costs for feedstocks such as ethylene and benzene. These firms are finding it hard to pass

Chemical industry leaders for the fourth quarter . . .

Sales			Earnings[a]			Profitability		
Rank 1988	$ Millions	Rank 1987		$ Millions	Rank 1987		Earnings as % of sales	Rank 1987
1 Dow Chemical	$4299.0	1	Dow Chemical	$635.0	1	Georgia Gulf	19.2%	1
2 Union Carbide	2139.0	3	Union Carbide	219.0	2	Arco Chemical	18.0	3
3 Monsanto	1881.0	2	Arco Chemical	134.0	3	Vista Chemical	16.1	2
4 W. R. Grace	1651.7	4	Quantum Chemical	119.3	4	Quantum Chemical	14.8	11
5 American Cyanamid	1103.1	5	American Cyanamid	62.8	4	Dow Chemical	14.8	7
6 Quantum Chemical	806.7	7	Air Products	61.1	6	Aristech	13.5	12
7 Hercules	749.0	6	Ethyl	58.9	8	International Flavors	12.8	4
8 Arco Chemical	745.0	11	W. R. Grace	55.5	7	Ethyl	11.4	5
9 Air Products	640.6	8	Georgia Gulf	54.4	12	Loctite	10.9	10
10 Olin	623.0	12	B. F. Goodrich	52.5	13	Betz Laboratories	10.7	6
						Nalco Chemical	10.7	8

. . . and for full-year 1988

Sales			Earnings[a]			Profitability		
Rank 1988	$ Millions	Rank 1987		$ Millions	Rank 1987		Earnings as % of sales	Rank 1987
1 Dow Chemical	$16,682.0	1	Dow Chemical	$2410.0	1	Arco Chemical	18.3%	2
2 Union Carbide	8,324.0	3	Union Carbide	720.0	3	Georgia Gulf	18.3	3
3 Monsanto	8,293.0	2	Monsanto	591.0	2	Vista Chemical	16.1	7
4 W. R. Grace	5,786.1	4	Arco Chemical	494.0	5	Aristech	15.4	14
5 American Cyanamid	4,592.0	5	Quantum Chemical	382.7	6	International Flavors	15.3	1
6 Quantum Chemical	2,921.9	7	American Cyanamid	305.6	4	Dow Chemical	14.4	10
7 Hercules	2,802.0	6	Ethyl	231.0	9	Quantum Chemical	13.1	5
8 Arco Chemical	2,700.0	11	Rohm & Haas	230.1	8	Ethyl	11.5	4
9 Rohm & Haas	2,535.0	8	B. F. Goodrich	220.9	14	Betz Laboratories	10.8	6
10 Air Products	2,489.6	9	Air Products	219.5	10	Nalco Chemical	10.7	9

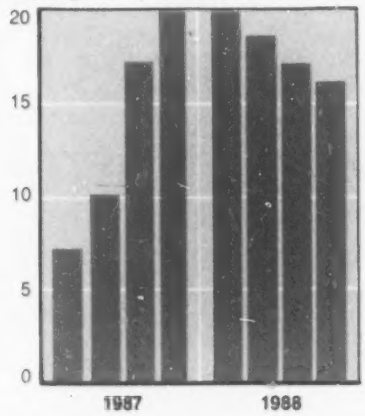
Note: for 30 companies listed on page 11. a After taxes.

Chemical industry 1988 fourth-quarter results

- Sales rose 16%
- Earnings soared 56%
- Profit margins at 9.2%
- Production gained 9.3%
- Prices increased 11%

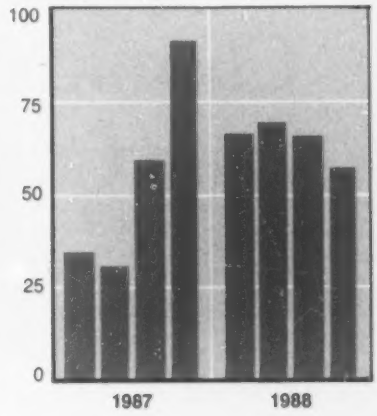
Sales

% change from year-earlier quarter



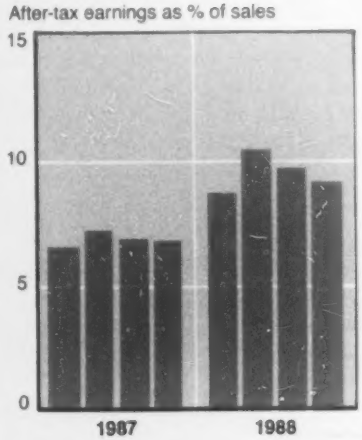
Earnings

% change from year-earlier quarter



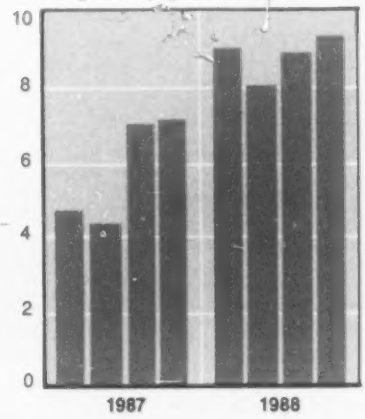
Profit margins

After-tax earnings as % of sales



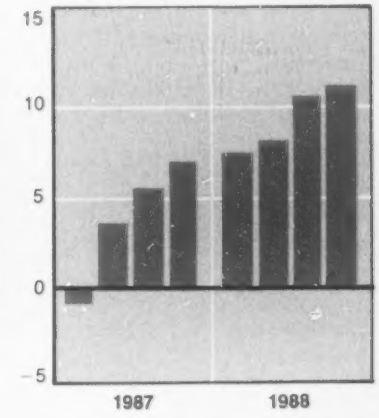
Production

% change from year-earlier quarter



Prices

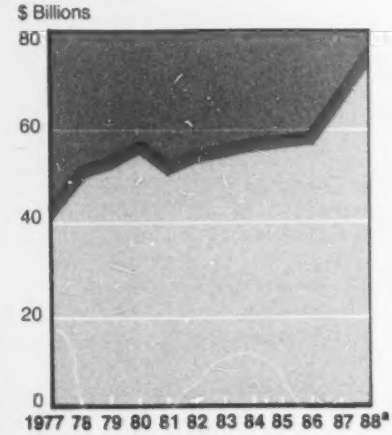
% change from year-earlier quarter



Sales in 1988 increased 19% and earnings climbed 61%, yielding a profit margin of 9.6%

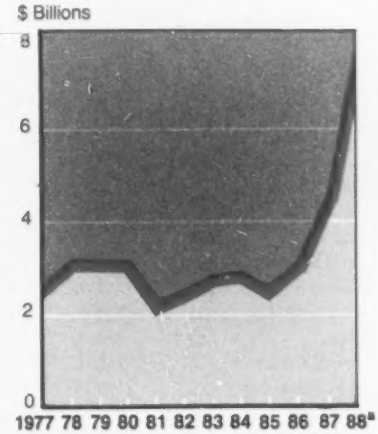
Annual sales

$ Billions



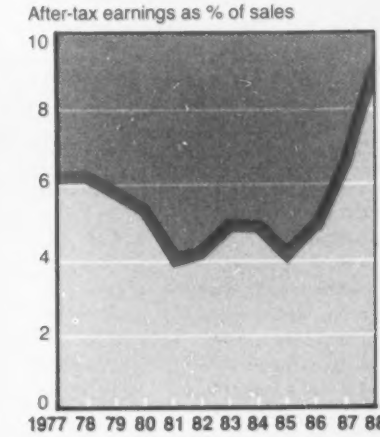
Annual earnings

$ Billions



Annual profit margins

After-tax earnings as % of sales



Note: All sales, earnings, and profit margin data are based on combined results of 30 companies on page 11. a C&EN estimates.

Fourth-quarter profits for 29 major chemical companies climbed 56% to $1.82 billion

	FOURTH-QUARTER 1988						FULL-YEAR 1988					
	Sales	Earnings[a]	Change from 1987		Profit margin[b]		Sales	Earnings[a]	Change from 1987		Profit margin[b]	
	($ millions)		Sales	Earnings	1988	1987	($ millions)		Sales	Earnings	1988	1987
Air Products[c]	$ 640.6	$ 61.1	9%	10%	9.5%	9.4%	$ 2,489.6	$ 219.5	14%	24%	8.8%	8.1%
American Cyanamid[c]	1,103.1	62.8	8	4	5.7	5.9	4,592.0	305.6	10	16	6.7	6.3
Arco Chemical[c]	745.0	134.0	47	116	18.0	12.2	2,700.0	494.0	38	92	18.3	13.2
Aristech	258.5	34.9	7	63	13.5	8.8	1,065.2	164.5	16	136	15.4	7.6
Betz Laboratories	115.1	12.4	15	23	10.7	10.1	447.6	48.4	16	19	10.8	10.5
Cabot Corp.[c]	480.1	22.8	24	40	4.7	4.2	1,769.9	61.8	28	7	3.5	4.2
Chemed	146.2	3.7	47	−22	2.5	4.7	500.6	20.6	28	1	4.1	5.2
Crompton & Knowles	85.6	4.2	66	28	4.9	6.3	289.8	16.8	45	40	5.8	6.0
Dow Chemical[c]	4,299.0	635.0	20	79	14.8	9.8	16,682.0	2410.0	25	94	14.4	9.3
Ethyl[c]	515.5	58.9	10	11	11.4	11.2	2,011.5	231.0	17	19	11.5	11.2
First Mississippi	96.3	6.1	12	95	6.3	3.6	331.5	25.3	2	19	7.6	6.5
H. B. Fuller	180.9	4.8	18	−34	2.7	4.8	685.0	21.1	15	−18	3.1	4.3
Georgia Gulf	283.6	54.4	40	55	19.2	17.4	1,060.6	193.6	50	111	18.3	13.0
B. F. Goodrich[c]	617.7	52.5	16	82	8.5	5.4	2,416.7	220.9	19	149	9.1	4.4
W. R. Grace[c]	1,651.7	55.5	27	4	3.4	4.1	5,786.1	192.1	28	35	3.3	3.1
Hercules[c]	749.0	23.4	10	−52	3.1	7.1	2,802.0	142.7	4	−32	5.1	7.8
International Flavors	181.3	23.2	1	9	12.8	11.9	839.5	128.7	13	20	15.3	14.3
International Minerals	241.0	15.0	14	2	6.2	6.9	1,054.1	87.9	nc	nc	8.3	4.2
Loctite	112.8	12.3	9	28	10.9	9.3	474.9	47.7	24	30	10.0	9.6
Lubrizol	na	na	na	na	na	5.2	na	na	na	na	na	8.0
Monsanto[c]	1,881.0	45.0	2	2	2.4	2.4	8,293.0	591.0	9	36	7.1	5.7
Nalco Chemical	262.0	28.1	14	27	10.7	9.6	994.2	106.0	18	32	10.7	9.5
Olin[c]	623.0	21.0	24	24	3.4	3.4	2,308.0	98.0	20	26	4.2	4.0
Pennwalt	263.5	13.2	23	104	5.0	3.0	1,023.6	48.3	21	46	4.7	3.9
Petrolite	74.2	2.1	−5	−42	2.9	4.7	301.4	13.0	8	−16	4.3	5.6
Quantum Chemical[c]	806.7	119.3	21	98	14.8	9.0	2,921.9	382.7	29	52	13.1	11.1
Rohm & Haas[c]	594.6	42.3	12	15	7.1	6.9	2,535.0	230.1	15	18	9.1	8.9
Union Carbide[c]	2,139.0	219.0	16	188	10.2	4.1	8,324.0	720.0	20	153	8.6	4.1
Vista Chemical	191.2	30.8	7	21	16.1	14.2	790.8	127.5	20	95	16.1	10.0
Witco[c]	384.0	20.4	4	57	5.3	3.5	1,585.9	71.6	11	13	4.5	4.4
Total 15 larger firms	**$17,229.9**	**$1572.9**	**16%**	**61%**	**9.1%**	**6.6%**	**$67,217.5**	**$6371.0**	**19%**	**62%**	**9.5%**	**7.0%**
Smaller 15 firms[d]	**$ 2,492.2**	**$ 245.3**	**17%**	**30%**	**9.8%**	**8.8%**	**$ 8,804.8**	**$ 961.4**	**21%**	**55%**	**10.9%**	**8.5%**
GRAND TOTAL[d]	**$19,722.1**	**$1818.2**	**16%**	**56%**	**9.2%**	**6.9%**	**$76,022.3**	**$7332.4**	**19%**	**61%**	**9.6%**	**7.2%**

a After-tax earnings from continuing operations excluding significant nonrecurring and extraordinary items. b After-tax earnings as a percentage of sales. c One of the 15 larger companies. d Totals for the quarter exclude Lubrizol. Totals for the full year exclude Lubrizol and International Minerals whose full-year figures are not comparable. na = not available. nc = not comparable.

along these increased costs to their customers.

For instance, at Vista Chemical, whose sales continued strong, president and chief executive officer John D. Burns said that the generally good results were affected negatively by higher costs for ethane and benzene, two of the company's principal feedstocks.

In spite of the profit squeeze at a few companies, the fundamentals of the industry remained strong. High demand for most chemical products, both in the U.S. and internationally, caused continued high operating rates at chemical plants. Government figures put capacity utilization for chemicals and allied products at about 90% in the fourth quarter, up from about 86% in the same period in 1987. And in some cases, especially among commodity plastics, according to industry sources, capacity use is much higher than this.

As a result, earnings growth for the industry remained robust in the quarter. For 29 of the 30 companies regularly surveyed by C&EN, earnings from continuing operations climbed 56% to a total of almost $1.82 billion on a sales rise of 16% to about $19.7 billion. Lubrizol's quarterly results have not been released.

Profit margins for the 29 firms rose to an average of 9.2% in the fourth quarter from just 6.9% in the year-earlier period.

The biggest gains were at the 15 larger firms in the group, earnings of which soared 61% to $1.57 billion in the fourth quarter. For the smaller 15 firms, earnings rose 30% to $245 million. But the sales gain for the smaller companies slightly outpaced that for the larger firms. Sales for the 15 larger companies rose 16% to $17.2 billion. For the smaller companies, sales increased 17% to $2.49 billion.

Profitability was higher for the smaller companies than for the larg-

Earnings increased at most oil, diversified companies

	FOURTH-QUARTER 1988						FULL-YEAR 1988					
	Sales	Earnings[a]	Change from 1987		Profit margin[b]		Sales	Earnings[a]	Change from 1987		Profit margin[b]	
	($ millions)		Sales	Earnings	1988	1987	($ millions)		Sales	Earnings	1988	1987
OIL AND GAS COMPANIES												
American Petrofina	$ 675.5	$ 32.9	1%	142%	4.9%	2.0%	$ 2,634.7	$ 132.9	6%	60%	5.0%	3.4%
Amoco	5,526.0	375.0	4	−1	6.8	7.1	21,157.0	2063.0	5	52	9.8	6.7
Ashland	2,100.0	96.0	5	20	4.6	4.0	8,208.0	239.7	11	29	2.9	2.5
Atlantic Richfield	4,548.0	391.0	−2	15	8.6	7.4	18,324.0	1583.0	8	29	8.6	7.2
Chevron	6,900.0	441.0	−7	63	6.4	3.7	28,900.0	1691.0	−1	70	5.9	3.4
Exxon	22,020.0	1380.0	1	−11	6.3	7.1	87,542.0	5250.0	5	8	6.0	5.8
Kerr-McGee	689.5	33.4	8	127	4.9	2.3	2,743.2	110.1	5	31	4.0	3.2
Mobil	13,886.0	448.0	−2	14	3.2	2.8	54,877.0	2038.0	7	67	3.7	2.4
Occidental Petroleum	5,284.0	52.0	20	126	1.0	0.5	19,417.0	358.0	14	95	1.8	1.1
Phillips Petroleum	2,860.0	135.0	−2	309	4.7	1.1	11,490.0	650.0	5	1757	5.7	0.3
Shell Oil	5,458.0	212.0	−7	−51	3.9	7.4	21,399.0	1204.0	1	−2	5.6	5.8
Sun Co.	2,720.0	93.0	4	−5	3.4	3.8	10,000.0	321.0	2	−12	3.2	3.7
Texaco	8,469.0	538.0	−10	55	6.4	3.7	35,138.0	2281.0	−1	78	6.5	3.6
Unocal	2,635.0	43.0	13	48	1.6	1.2	10,085.0	267.0	7	48	2.6	1.9
DIVERSIFIED MANUFACTURERS												
Allied-Signal	3,007.0	104.0	2	35	3.5	2.6	11,909.0	360.0	7	−8	3.0	3.5
Borden	1,983.3	93.9	10	15	4.7	4.5	7,243.5	31.9	11	−88	0.4	4.1
Du Pont	8,441.0	500.0	6	14	5.9	5.5	32,917.0	2190.0	8	23	6.7	5.9
Eastman Kodak	4,543.0	312.0	29	29	6.9	6.9	17,034.0	1397.0	28	19	8.2	8.9
Engelhard	695.1	19.2	−5	5	2.8	2.5	2,350.7	63.7	−5	8	2.7	2.4
FMC	882.1	36.0	3	555	4.1	0.6	3,286.9	129.2	5	34	3.9	3.1
Ferro Corp.	260.8	11.8	12	26	4.5	4.0	1,009.0	46.6	16	47	4.6	3.6
3M	2,579.0	272.0	9	26	10.5	9.1	10,581.0	1154.0	12	26	10.9	9.7
Morton-Thiokol	631.9	38.9	8	−1	6.2	6.7	2,461.1	159.7	14	15	6.5	6.4
PPG Industries	1,400.0	102.3	8	6	7.3	7.4	5,600.0	467.6	8	24	8.4	7.3
Vulcan Materials	267.4	25.1	9	−12	9.4	11.6	1,053.2	136.0	14	19	12.9	12.4
Tyler	167.7	0.8	7	−87	0.5	3.6	664.6	14.6	6	−38	2.2	3.8

a After-tax earnings from operations excluding significant nonrecurring and extraordinary items. b After-tax earnings as a percentage of sales.

er ones, although profit margins for the larger firms showed a stronger improvement. At the 15 larger companies, profit margins for the fourth quarter averaged 9.1%, up from 6.6% in the same period in 1987. For the smaller companies, the average profit margin was 9.8%, up from 8.8% in the year-earlier period. The average profit margin is calculated from the total sales and earnings for each group.

For the full year, the results were even more impressive than they were for the quarter. Earnings for 28 of the 30 companies surveyed rose 61% in 1988 to $7.33 billion on a sales increase of 19% to $76.0 billion. For the full-year totals, Lubrizol is not included, nor is International Minerals & Chemical (because of the spinoff of IMC Fertilizers into a separate company, data are not comparable).

Profit margins for the 28 companies averaged 9.6% in 1988, up considerably from 7.2% for 1987.

The full-year breakdown between the larger and smaller companies was similar, but not as drastic in difference, to that for the fourth quarter. Earnings for the 15 larger firms for all of 1988 rose 62% to $6.37 billion on a sales increase of 19% to $67.2 billion. The 13 smaller companies recorded earnings up 55% to $961 million on a sales increase of 21% to $8.80 billion.

As a result, the average profit margin for the larger companies increased to 9.5% in 1988 from 7.0% in 1987; that for the smaller companies rose to 10.9% last year from 8.5% in 1987.

The role of commodities as major contributors to earnings was confirmed by chemical results at oil companies during the quarter. Results from largely commodity-based chemical operations at eight major oil companies (Amoco, Atlantic Richfield, Chevron, Mobil, Occidental Petroleum, Shell, Texaco, and Unocal) show a 102% earnings gain for the quarter to $1.13 billion. For the year, earnings of these firms rose an average of 110% to $4.08 billion.

These results are inflated somewhat by Occidental's acquisition of Cain Chemical in May of 1988. Even without Occidental, however, the remaining seven companies registered a 76% gain for the quarter and an increase of 98% for the year.

Despite the good results, there are a few worrisome signs for the

Profits of most major pharmaceutical companies climbed

Earnings for major U.S. pharmaceutical firms rose markedly in the fourth quarter, registering an increase that outpaced that for the earlier quarters of 1988. Fourth-quarter earnings for 12 major drug companies surveyed by C&EN increased 33% from last year's fourth quarter to a total of almost $1.58 billion on a sales increase of just 9% to $11.7 billion.

For the full year, the earnings gain for the 12 firms was 20% to an aggregate $6.70 billion on a 12% sales gain to $45.8 billion.

As a result, profitability rose for the companies. The average profit margin for the 12 climbed to 13.5% in the fourth quarter from 11.2% in the same period in 1987. For the full year, the average profit margin was 14.6%, compared with an average 13.6% for the previous year.

Although most of the companies recorded fairly strong gains in the fourth quarter, earnings for two companies declined. Profits at financially troubled SmithKline Beckman dropped 20% to $113 million on a 7% sales rise to almost $1.28 billion. Henry Wendt, chairman and chief executive officer, said, "There is much work to be done to restore growth. But there were many positive developments in 1988, beginning with the creation of a unified worldwide pharmaceutical business." Wendt also cited gains in international pharmaceutical sales and "solid contributions to earnings" by other health care businesses.

But overall, SmithKline's ethical pharmaceutical sales declined, led by a fall in U.S. sales of its Tagamet antiulcer drug and Dyazide, a diuretic/antihypertensive.

A. H. Robins, the other company whose earnings fell and which has been left weakened by its Chapter 11 bankruptcy proceedings brought on by litigation over its Dalkon Shield intrauterine device, gave no reason for the decrease.

Chemical operations at drug companies showed mixed results. Eli Lilly had fourth-quarter sales of $798 million, an increase of 7% from the previous year. Higher sales of the herbicides Treflan and Sonalan were the primary contributors.

At Pfizer, fourth-quarter results showed a 9% decline in specialty chemical sales, a 6% drop in agriculture sales, and a 3% decline in materials science sales.

Merck, the remaining drug company with large chemical sales, did not comment about its results.

	FOURTH-QUARTER 1988						FULL-YEAR 1988					
	Sales	Earnings[a]	Change from 1987		Profit margin[b]		Sales	Earnings[a]	Change from 1987		Profit margin[b]	
	($ millions)		Sales	Earnings	1988	1987	($ millions)		Sales	Earnings	1988	1987
American Home Products	$1300.9	$238.6	7%	11%	18.3%	17.7%	$5500.5	$932.2	9%	10%	16.9%	16.8%
Bristol-Myers	1479.5	195.6	9	12	13.2	12.8	5972.5	829.0	11	17	13.9	13.1
Eli Lilly	1042.3	175.7	15	def	16.9	def	4069.7	761.0	12	85	18.7	11.3
Merck	1534.1	307.3	10	32	20.0	16.7	5939.5	1206.8	17	33	20.3	17.9
Pfizer	1368.2	141.6	7	4	10.3	10.7	5385.4	791.3	9	15	14.7	14.0
Rorer Group	325.2	26.9	16	20	8.3	8.0	1041.6	61.8	12	14	5.9	5.9
Schering-Plough	739.9	92.9	12	24	12.6	11.3	2969.4	389.8	10	23	13.1	11.7
SmithKline Beckman	1276.9	113.3	7	−20	8.9	11.8	4749.0	475.7	10	−17	10.0	13.2
Squibb	664.8	97.5	12	15	14.7	14.3	2585.8	425.5	20	19	16.5	16.6
A. H. Robins	241.0	32.1	3	−46	13.3	25.2	933.8	132.5	9	11	14.2	14.0
Upjohn	710.5	80.7	9	14	11.4	10.9	2746.2	353.4	9	16	12.9	12.1
Warner Lambert	997.9	77.5	11	17	7.8	7.4	3908.4	340.3	14	15	8.7	8.8

a After-tax earnings from operations excluding significant nonrecurring and extraordinary items. b After-tax earnings as a percentage of sales. def = deficit.

future. One of these is that the growth in earnings has been slowing for the past three quarters (albeit earnings are being compared with increasingly stronger quarters).

Government reports of seasonally adjusted shipments of chemicals and allied products show month-to-month declines in November and December. At the same time inventories have been building. Inventories also have been building for these two months for the narrower industrial chemicals category and month-to-month shipments for this category declined in December.

Also, shipments data for plastics published by the Society of the Plastics Industry show the same general pattern—a slowing in the latter part of the year.

It may, however, be too soon to tell. The shipments and inventory data may simply be a result of year-end inventory adjustments by downstream customers. This, at least, is what companies seem to be saying.

Georgia Gulf's James R. Kuse, chairman and chief executive officer, says, "Overall supply and demand for the products we produce were in close balance for most of the year. As a result, nearly all of our plants operated at or near capacity with very little accumulation of inventories at either plant or customer levels. There was, however, some general leveling of demand from earlier peak periods during the latter part of the fourth quarter."

At Aristech, chairman Thomas Marshall says that polypropylene is not expected to be so strong a performer as in 1988. As the year ended, there was some compression in margins. This was a result of a severe reduction in purchases by China coupled with capacity increases at

four U.S. producers. Marshall adds that raw material prices also began to escalate in the fourth quarter.

In spite of what at this time seem to be only small worries, most companies are predicting a good 1989.

B. F. Goodrich says that polyvinyl chloride sales slowed in the fourth quarter because of seasonal factors, but early indications are that shipments of the plastic will continue to grow in 1989.

Dow president and chief executive officer Frank P. Popoff states, "While 1988 was an outstanding year for the company, Dow management is clearly focused on continued profit growth in 1989 and beyond."

At Du Pont, the largest U.S. chemical producer, chairman Richard E. Heckert comments, "We look forward to further earnings improvement in 1989. The economic outlook for 1989 calls for moderate growth and potential stability for crude oil prices. In this environment we expect to maintain the momentum built by our businesses in recent years, further improving shareholder value." □

Plastics expected to retain competitive edge

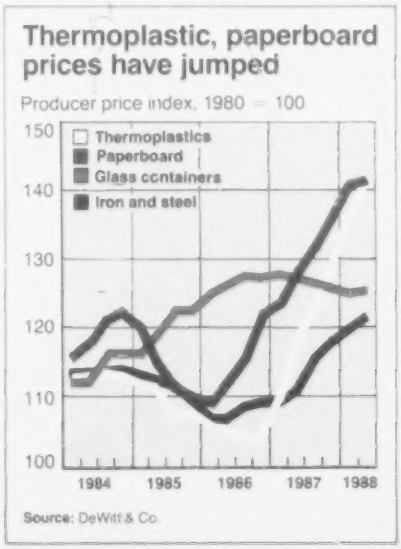
Plastics will hold the edge in the ever-increasing competition among materials despite rapid price rises last year. With additional capacity coming to ease current demand pressures, plastics will continue to improve their position. Cost/performance improvement through continuing innovation will give plastics a bigger share of markets such as packaging and automotive at the expense of metals, glass, and paper.

Better performance remains the key to demand for plastics growing significantly faster than demand for other materials. Cost is very important, but higher-priced plastics offer so much better performance that they will continue to replace other materials. These were some of the major conclusions of the Chemical Marketing Research Association meeting held in Houston earlier this month on the outlook for competing materials and technologies.

The prices of some materials competing with plastics also have increased markedly, notes William C. Kuhlke, a specialist in studies of volume plastics and vice president of De Witt & Co., a Houston-based consulting firm. By the middle of 1988, the price of paperboard, for example, increased about the same as that of thermoplastics, even though prices of thermoplastics such as low-density polyethylene had risen 34% and general-purpose polystyrene had skyrocketed 106% from lows in 1986. There are a few temporary shifts to other materials from plastics because of higher prices—for instance, ductile iron is replacing polyvinyl chloride in large-diameter pipe.

To have a lasting major shift in materials, however, two things must happen, Kuhlke says. First, the new material must have properties equal to or superior to those of existing materials, offer a dramatic performance improvement such as resistance to corrosion or to shattering, or eliminate manufacturing steps. Second, the price differential must be large, 10% or more, to justify converting to a new material. The differential also must be expected to continue for an extended period.

For instance, the higher cost of raw materials for polyethylene terephthalate (PET) in 1988 adversely affected its growth in soft-drink bottles, according to Fred W. Voigt Jr., an Eastman Chemical Products market research associate. For the first time, demand for PET in bottles in the second half of a year was lower than in the first half. But PET use will continue to grow in the soft-drink container industry for several reasons, he says, one of which is the tight supply of aluminum. In addition, PET producers have a capital cost advantage over aluminum producers. For instance, for the same amount of capacity for producing soft-drink containers, aluminum producers would have to invest about double the capital—for smelter capacity—compared with what PET producers would have to invest for capacity starting with ethylene and *p*-xylene.



In the automotive industry, innovation will cause further shifts to the use of plastics. For example, rapid growth in applications is expected for a new glass-fiber-reinforced polypropylene composite developed by Exxon Chemical Americas, says Richard M. Burkhart, the company's venture manager for structural thermoplastic composites. These composites are finding increased acceptance in the automotive industry because of cost savings in tooling, labor, and materials, and because they provide greater design flexibility.

North American automakers consumed between 25 million and 30 million lb of fabricated composites last year, according to Burkhart. With growth at 15 to 20% per year, demand for these items in both existing and new applications is projected to exceed 200 million lb by the year 2000.

Plastics also compete with other plastics. Performance can make nylon film a better material than polyethylene film for the carrier web used in fabricating sheet-molding compound, a matrix of a resin-filler paste and glass fibers, according to Olinda W. Rush, Allied-Signal's product manager for composite fabrication materials. The higher cost of nylon film is partially offset by the use of 1-mil film instead of the 2-mil film required if polyethylene is used. Less scrap and breakage result, further reducing the cost disadvantage of nylon film in making sheet-molding compound.

Bruce Greek

Bush Budget Proposal Calls For Increases in R&D Funding

Proposal favors budget increases for basic research, big science projects such as the Superconducting Super Collider, science education

David J. Hanson and Janice R. Long, C&EN Washington

As promised, President George Bush unveiled his plan for "building a better America" on Feb. 9. His first budget plan is generally more than kind to science, as was Bush in his first State of the Union message to Congress. In the budget and the address, Bush said he favors increased funding for basic research, supports big science projects such as the Superconducting Super Collider, and wants to improve science education.

With his emphasis on R&D, particularly basic research, as a means of advancing American competitiveness and encouraging economic growth, Bush sounded uncannily like his predecessor, Ronald Reagan. Bush suggests fiscal 1990 funding levels for R&D that are close to what Reagan proposed on Jan. 9 (C&EN, Jan. 16, page 6). And where the numbers aren't identical, they are, in many cases, higher rather than lower.

For example, Bush told Congress, "I propose almost $2.2 billion for the National Science Foundation to promote basic research and keep us on track to double its budget by 1993." Reagan proposed a fiscal 1990 NSF funding level of $2.15 billion, which can easily be rounded off to the same amount as in Bush's proposal.

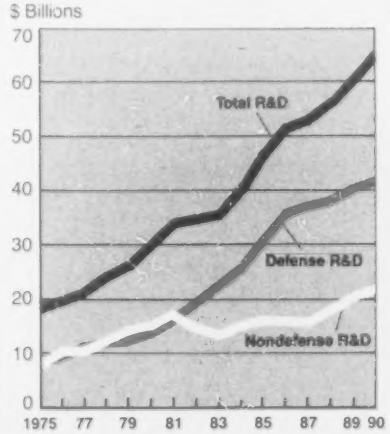
According to the Bush budget document, this 14% increase will allow NSF to support the engineering research centers, the advanced scientific computing centers, and the 11 interdisciplinary science and technology centers announced in 1988, plus thousands of individual researchers at universities and colleges, all of which NSF was already planning to do under the Reagan budget proposal.

NSF clearly falls into a category—"Advancing Priorities for Growth and Competitiveness"—that is one of five "key priority" categories that the Bush Administration has targeted for funding increases in the coming fiscal year. Competitiveness is to be enhanced by increasing federal investments in R&D even beyond the current strong level.

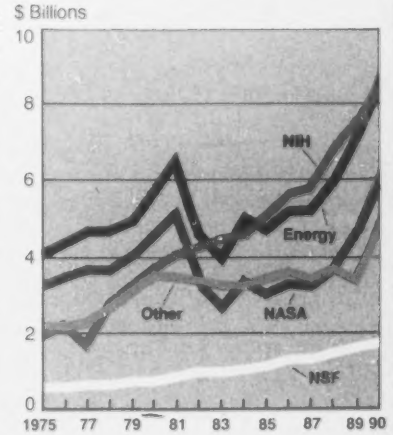
Also falling into that category, and thus candidates for budget increases, are Department of Energy general science programs, funding of which was slated to rise almost 30% in the Reagan budget proposal. And DOE's Superconducting Super Collider is singled out as a "critical part of this Administration's initiative to strengthen the position of the nation as a world leader in science and technology. . . . It will produce discoveries, innovations, and spinoffs that could touch profoundly every American." Thus, Bush is seeking budget authority of $250 million in 1990, again identical to Reagan's proposal, for the federal share of construction funding for the collider.

But he parts company with Reagan in seeking $710 million, an increase of 274% over 1989 funding, for DOE's clean coal technology program. Reagan had asked for $325 million for the program. The increased funding reflects Bush's commitment "to ending the long debate on acid rain. The time for action has come," say the budget documents. In addition to honoring the U.S. pledge to Canada to devote $2.5 billion in federal funds over five years for the clean coal tech-

Defense now accounts for 65% of R&D spending . . .



. . . and Energy has largest share of nondefense budget



Note: Outlays. Source: Office of Management & Budget

nology program, the Bush Administration intends to ask Congress to establish an acid rain program that will obtain significant reductions in sulfur dioxide and nitrous oxides within a specified period.

To provide real reductions as quickly and efficiently as possible, the Administration says its legislation will provide market-based incentives for early deployment of innovative emission reduction techniques and will remove disincentives to the use of clean-burning fuels like natural gas, methanol, and ethanol.

In his State of the Union message Bush told Congress, "I request funding for the National Aeronautics & Space Administration and a strong space program: an increase of almost $2.4 billion over the current fiscal year. We must have a manned space station, a vigorous, safe space shuttle program, and more commercial development in space. The space program should always go 'full throttle up.' That's not just our ambition, it's our destiny." Reagan requested a $2.2 billion increase to $13.1 billion for NASA.

In the Reagan proposal, NASA's R&D budget was up 22%, with much of the increase slated for the controversial space station, up 125% to $2 billion. Bush calls "Space Station Freedom" the keystone of the U.S. space policy. He also believes in a balanced and flexible space transportation program and would supply enough funds to the space shuttle program for nine flights in fiscal 1990.

Bush has also committed himself to improved biomedical research, and his budget recommendations declare that basic research in medicine is a public good that would be underfunded without the federal investment. He sees the need for advanced training of top quality, highly skilled biomedical researchers.

Here Bush again parts company with Reagan, proposing an overall 3.6% increase for biomedical R&D (excluding research on acquired immune deficiency syndrome) and, within that, a 6.6% increase for basic biomedical research. Also excluding AIDS research, Reagan had asked for a 5% cut in the National Institutes of Health's R&D budget

TOTAL FEDERAL R&D BUDGET PROPOSAL

Obligations for R&D are up 7% in 1990. . .

	Obligations			Outlays		
$ Millions	1990[a]	1989[a]	1988[b]	1990[a]	1989[a]	1988[b]
Defense[c]	$41,518	$38,879	$37,063	$39,437	$37,306	$35,417
Health & Human Services	8,375	7,892	7,181	8,094	7,345	6,862
NASA	6,870	5,688	4,339	6,152	4,741	3,832
Energy	5,378	5,307	5,081	5,501	5,259	4,969
NSF	1,881	1,664	1,533	1,756	1,634	1,494
Agriculture	1,044	1,048	1,014	1,043	1,020	972
Interior	387	432	415	391	432	415
EPA	421	386	347	405	364	340
Transportation	332	329	304	384	391	321
Veterans Affairs	205	238	217	201	208	199
Commerce	201	441	561	278	449	413
Agency for International Development	177	184	193	218	222	234
All other	556	563	554	560	527	529
TOTAL	$67,345	$63,051	$58,773	$64,418	$59,898	$56,017

Note: Excludes R&D facilities funding. a Reagan Administration estimate. b Actual. c Includes military-related R&D programs of the departments of Defense and Energy. Source: Office of Management & Budget

. . . and basic research commitments are up 6% . . .

	Obligations			Outlays		
$ Millions	1990[a]	1989[a]	1988[b]	1990[a]	1989[a]	1988[b]
Health & Human Services	$4,756	$4,417	$4086	$4,521	$4,152	$3914
NSF	1,754	1,553	1433	1,638	1,527	1399
NASA	1,462	1,438	1113	1,407	1,318	1019
Energy	1,389	1,303	1183	1,402	1,304	1171
Defense[c]	929	939	873	954	936	839
Agriculture	511	490	477	499	479	457
Interior	128	147	126	131	148	129
Smithsonian Institution	87	79	75	85	78	73
EPA	76	44	27	73	40	28
Commerce	28	30	31	29	31	28
Veterans Affairs	16	19	17	16	18	16
All other	24	28	27	25	26	28
TOTAL	$11,160	$10,487	$9468	$10,880	$10,057	$9099

a Reagan Administration estimate. b Actual. c Includes military-related R&D programs of the departments of Defense and Energy. Source: Office of Management & Budget

. . . but R&D facilities obligations are down 1%

	Obligations			Outlays		
$ Millions	1990[a]	1989[a]	1988[b]	1990[a]	1989[a]	1988[b]
Energy	$1089	$ 904	$ 921	$ 968	$ 888	$ 886
NASA	589	561	428	511	484	399
Defense	520	604	450	500	466	422
NSF	86	60	57	80	65	57
Agriculture	58	109	135	136	113	78
Health & Human Services	22	146	22	52	72	33
All other	68	69	90	69	63	57
TOTAL	$2432	$2453	$2093	$2316	$2161	$1932

a Reagan Administration estimate. b Actual. Source: Office of Management & Budget

HOW THE AGENCIES FARE

Health research gains from AIDS funding

$ Millions	1990*	1989*	1988*	% change 1988–89
National Institutes	$8078.0	$6564.4	$6068.8	8%
Cancer	1646.1	1571.5	1469.3	5
Heart, Lung & Blood	1082.5	1045.9	985.5	3
General Medical Sciences	781.3	682.3	638.0	15
Diabetes & Digestive & Kidney Diseases	582.6	559.7	534.7	4
Neurological & Communicative Disorders & Stroke	502.0	480.2	459.0	5
Allergy & Infectious Diseases	842.7	743.6	640.3	19
Child Health & Human Development	444.2	426.6	396.6	4
Eye	239.5	231.3	224.6	4
Environmental Health Sciences	230.8	223.7	215.7	3
Aging	230.5	222.8	194.7	3
Arthritis & Musculoskeletal & Skin Diseases	168.6	160.0	147.7	5
Dental Research	135.8	130.8	126.3	4
Deafness	91.4	87.0	75.7	5
Other	434.4	515.6	523.2	−25
TOTAL	$7412.4	$7078.4	$6611.8	5%

Note: Obligations for AIDS research have been added to each individual institute. a Reagan Administration estimate. b Actual. Source: National Institutes of Health, Office of Management & Budget

. . . funding for the sciences is up 10% . . .

$ Millions	1990*	1989*	1988*	% change 1988–89
Ocean sciences	$ 152.9	$ 146.2	$134.8	5%
Materials research	135.2	115.0	110.6	18
Physics	130.0	122.6	117.9	6
Atmospheric sciences	109.4	98.7	96.2	11
Chemistry	103.4	96.6	94.0	7
Astronomical sciences	94.0	89.5	85.8	5
Mathematical sciences	76.0	65.9	63.8	15
Biotic systems, resources	76.0	62.9	58.7	21
Earth sciences	65.2	54.2	51.3	20
Cellular biosciences	60.6	55.6	53.9	9
Molecular biosciences	51.4	46.6	44.5	10
Behavioral, neural sciences	48.3	44.8	43.6	8
Social, economic sciences	33.2	30.9	30.1	7
TOTAL	$1135.6	$1029.5	$935.3	10%

Note: Obligations. a Reagan Administration estimate. b Actual. Source: National Science Foundation

NSF's total budget is up 14% . . .

$ Millions	1990*	1989*	1988*	% change 1988–89
Mathematical and physical sciences	$ 563.5	$ 503.3	$ 472.0	10%
Geosciences	341.3	310.3	280.7	10
Biological, behavioral, and social sciences	314.5	281.5	265.1	12
Engineering	211.2	187.3	172.1	13
Computer and information science and engineering	191.2	152.1	123.9	26
Science and engineering education	190.0	171.0	139.2	11
Antarctic program	156.0	131.0	124.8	19
Program development and management	104.0	91.7	84.5	13
Scientific, technological, and international affairs	67.3	58.3	50.1	15
Science and technology research centers	20.0	0.3	0	566
TOTAL	$2149.0	$1886.8	$1722.4	14%

Note: Obligations. a Reagan Administration estimate. b Actual. Source: National Science Foundation

. . . and chemical programs are up 12%

$ Millions	1990*	1989*	1988*	% change 1988–89
Materials research	$135.2	$115.0	$110.6	18%
Project support	74.4	68.6	68.4	8
Laboratories and groups	36.2	34.3	33.6	6
National facilities	24.6	12.1	10.6	103
Chemistry	103.4	96.7	94.0	7
Physical	29.8	28.5	28.1	5
Organic and macromolecular	25.0	23.8	22.9	5
Inorganic, bioinorganic, and organometallic	16.6	16.0	14.2	4
Analytical and surface	13.5	12.7	12.0	6
Special projects	9.6	7.3	8.7	31
Instrumentation	8.9	8.4	8.4	6
Chemical and thermal systems engineering	36.0	33.3	31.7	8
Fluid, particulate, and hydraulic systems	9.9	9.3	8.9	6
Interfacial, transport, and seperation processes	9.9	8.7	7.8	14
Thermal systems	8.8	8.3	8.2	6
Chemical reaction processes	7.4	7.0	6.8	6
Biochemistry	14.5	13.5	13.2	7
Cellular biochemistry	12.7	11.9	11.5	7
TOTAL	$301.8	$270.4	$261.0	12%

Note: Obligations. a Reagan Administration estimate. b Actual. Source: National Science Foundation

and only a 3% rise in its basic research budget.

Under the Bush budget proposal, total spending for AIDS research by all federal agencies would be boosted to $1.6 billion, a rise of $313 million from fiscal 1989. To accelerate advances in medical research, Bush also hopes to see new partnerships formed between industry and the federal research establishment. He will allow Reagan's proposal for $100 million for the mapping of the human genome to stand, hoping that this initiative will promote American competitiveness and leadership in the health industries.

Bush's call for a freeze on real growth in defense spending probably means that Department of Defense R&D programs, which were slated to rise 9% in the Reagan budget proposal, would be held to the rate of inflation, which is forecast at about 4% in 1990. The freeze would apply for only one year, according to Bush. After that, he says, increases above inflation will be required.

The Reagan DOD R&D budget once_again proposed a major increase (54%) for the Strategic Defense Initiative (C&EN, Feb. 13, page 8). Bush has pledged that SDI will continue, but the $1.9 billion increase to $5.6 billion for 1990 may

Air, interdisciplinary R&D lead EPA rise

$ Millions	1990[a]	1989[a]	1988[b]	% change 1989–90
Air	$ 64.2	$ 69.1	$ 65.5	22%
Interdisciplinary	77.7	39.4	28.1	97
Superfund/underground tanks	69.3	73.8	54.6	−6
Hazardous waste	42.3	45.4	43.6	−7
Energy/acid rain	38.2	54.9	55.3	−30
Toxic substances	28.0	28.0	26.4	0
Water quality	26.3	24.2	24.4	9
Drinking water	23.3	21.5	22.4	8
Pesticides	14.3	13.6	12.7	6
Management & support	13.7	13.1	11.0	5
Radiation	4.2	3.6	2.7	17
TOTAL	$421.5	$386.5	$346.9	9%

Note: Obligations. a Reagan Administration estimate. b Actual. Source: Environmental Protection Agency

Cooperative research still down at USDA

$ Millions	1990[a]	1989[a]	1988[b]	% change 1989–90
Agricultural Research Service	$ 604.6	$ 584.3	$ 551.9	3%
Cooperative State Research Service	295.4	348.5	352.0	−15
Forest Service research	133.8	137.9	132.5	−3
National Agricultural Library	14.9	13.3	12.2	12
TOTAL	$1048.7	$1084.0	$1048.6	−3%

Note: Obligations. a Reagan Administration estimate. b Actual. Source: Department of Agriculture

Growth slows for DOD R&D

$ Millions	1990[a]	1989[a]	1988[b]	% change 1989–90
Conduct of R&D	$41,024	$37,643	$37,027	9%
Tactical programs	14,942	13,169	11,998	13
Advanced technology development	7,840	5,897	5,356	33
Strategic programs	5,628	6,481	7,227	−13
Intelligence and communications	4,697	4,499	4,885	4
Program management and support	4,624	4,019	4,251	15
Technology base	3,293	3,478	3,310	−5
R&D facilities	520	604	450	−14
TOTAL	$41,544	$38,147	$37,477	9%

Note: Obligations. a Reagan Administration estimate. b Actual. Source: Office of Management & Budget

Basic research paces rise in DOE R&D budget

$ Millions	1990[a]	1989[a]	1988[b]	% change 1989–90
ENERGY R&D	$3665.3	$3552.3	$3362.7	3%
Basic research	2027.0	1737.5	1619.4	17
General science	1186.5	918.9	894.3	27
High-energy physics	616.2	559.4	559.1	10
Nuclear physics	299.3	260.9	245.2	15
Superconducting Super Collider	250.0	98.6	0	154
Basic energy sciences	590.0	549.3	567.7	7
Materials sciences	202.5	180.5	170.3	12
Chemical sciences	149.9	132.9	127.2	13
Other	237.6	235.9	260.2	1
Biological, environmental research	271.5	269.3	257.6	1
Nuclear	352.9	364.9	347.0	−1
Magnetic fusion	349.3	351.1	331.2	−1
Clean coal technology	325.0	190.0	196.9	71
Fossil	163.6	390.6	337.0	−67
Supporting research activities	20.5	127.6	155.8	−6
Environmental safety, health	124.6	91.0	71.1	37
Solar and other renewables	112.5	156.8	148.1	−28
Conservation	97.9	182.6	156.2	−46
DEFENSE R&D	2614.9	2535.8	2511.9	3
Weapons R&D, testing	1962.9	1905.8	1004.9	3
Naval reactors development	652.0	630.0	607.0	3
TOTAL	$6279.2	$6088.1	$5864.6	3%

Note: Obligations. a Reagan Administration estimate. b Actual. Source: Department of Energy, Office of Management & Budget

Space station represents 33% of NASA R&D

$ Millions	1990[a]	1989[a]	1988[b]	% change 1989–90
Conduct of R&D	$5477.5	$4663.6	$3334.5	22%
Space station	1992.7	887.1	489.5	146
Physics and astronomy	886.5	765.0	585.8	16
Space capability development	641.1	848.2	598.8	−24
Space applications	580.8	724.9	577.5	−20
Aeronautical research	459.9	412.9	324.1	11
Planetary exploration	397.9	422.5	347.5	−6
Space research & technology	336.0	325.9	208.9	3
Life sciences	121.9	80.0	67.6	52
Transatmospheric vehicle	124.1	69.3	51.3	79
Commercial programs	60.2	84.9	48.9	−29
University space program	33.3	—	—	—
Safety & quality assurance	23.3	23.7	17.1	−2
Tracking & data acquisition	19.8	19.4	17.7	2
R&D facilities	341.8	275.1	213.2	24
TOTAL	$5819.3	$4938.9	$3547.7	22%

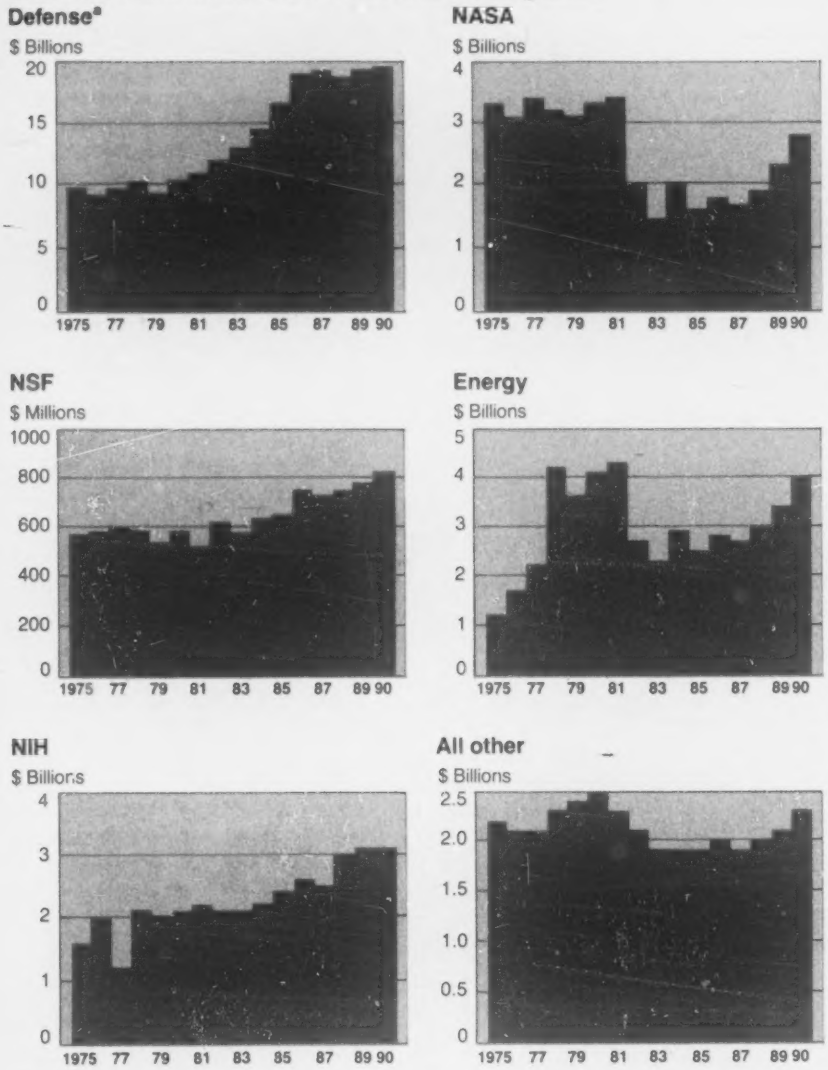
Note: Obligations. a Reagan Administration estimate. b Actual. Source: Office of Management & Budget

be in jeopardy. The basic research portion of the defense budget was slated for a 5% cut, to just under $3.2 billion. When President Bush made his proposal this month, defense spending was slated to rise only $9.1 billion compared with the Reagan rise of $15.4 billion, but a DOD spokesman says that specific changes to the budget have not yet been made. The department has 60 days in which to decide how it will meet Bush's target numbers. In Bush's outline for the 1990 budget, he gives no guidance on how defense R&D will be handled.

If one assumes that Bush's call for a freeze on domestic spending—no increases allowed for inflation—applies to all the programs not specifically targeted for increases, then a freeze might actually translate into good news for a few R&D funding agencies. The Department of Agriculture, for example, might welcome a freeze in its R&D budget, which was slated for a 3% cut by Reagan, as might the Department of Interior, whose R&D budget would be cut 10%, and the Department of Commerce, whose R&D budget was slated for a 55% cut.

However, it is bad news for the Environmental Protection Agency, whose R&D budget as a whole was up 9% under Reagan. Bush has made

Since 1975, defense R&D has doubled and NSF, Energy, and NIH R&D have also scored sizable gains



Note: Outlays in constant 1975 dollars. **a** Includes Department of Defense and Department of Energy military-related programs.
Source: Office of Management & Budget

a major commitment to environmental matters, but how that will be reflected in the agency's R&D budget remains to be seen. Overall, Reagan's EPA proposal will probably stand, although agency budget staffers say there could be some rearrangement of R&D priorities once the Bush people assume their positions. One of the largest increases would come in air quality research, where EPA would get about $14.1 million for assessing the global impact of climate change. This is a 440% increase over fiscal 1989 funding levels.

In other areas, Bush's budget proposal makes good on a number of promises he made during his Presidential campaign. For instance, in the education area, Bush is calling for establishment of a national science scholars program. Under the program, four-year scholarships of up to $10,000 per year would be provided for students majoring in the sciences, mathematics, or engineering. One student would be nominated for the program by each member and delegate in the House of Representatives, one by each Senator, and 30 by the President, for a total of 570 scholars each year. Annual competitions would be held to select nominees for the scholarships. The program would be funded at a level of $5 million in 1990, rising to $20 million per year by the fourth year.

Finally, the Bush budget contains some proposals that would affect the chemical industry. Again Bush follows Reagan's lead in calling for a permanent extension of the 20% research and experimentation tax credit and establishment of a liberalized base for calculating the amount of the credit. However, under the Bush plan, deductions for research expenditures would be reduced by the full amount, rather than the current 50%, of the credit taken.

In addition, Bush is advocating adoption of a permanent and "more beneficial" formula for allocating research and experimentation expenditures between domestic and foreign income. Bush's proposed rules would permit a 67% expense allocation to U.S. source income. The remaining portion would be allocated on the basis of gross sales or gross income, with no limitation on use of the gross income method, according to the budget documents.

However, Bush is also going along with the plan, first introduced in the Reagan budget, to generate revenues for the federal government from the phase-in of the international agreement reducing the use of chlorofluorocarbons to preserve the ozone layer. The Administration intends to charge the market value for the production rights remaining under the agreement.

As always, what the President proposes must be agreed to by Congress. So although Bush's budget proposals, particularly in the R&D area, are very similar, if not identical, to Reagan's, the chances of the numbers being the same when fiscal year 1990 begins are slim to zero. That's especially true this year, because Bush's budget proposal, although calling for increased funding in many areas, doesn't specify what other areas are to be cut to fund those increases and still meet the mandatory deficit reduction targets. He left that question open to negotiation. □